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The remaining tables in the memoir are designed to show the errors of mean refraction of the *Tabulæ*, and the arrangement is therefore according to the order of the zenith-distances of the stars. All the errors of mean refraction of the *Tabulæ* are reduced to errors of the *Fundamenta* by comparison of the errors of the two sets of tables, and the errors of the *Fundamenta* are then grouped for convenient intervals of zenith-distance, and the results derived from the three lists of stars are finally combined.

The conclusions derived from the whole investigation, with regard to errors of mean refraction, are the following :—

1. As far as 82° zenith-distance the mean refractions of the *Tabulæ* are very nearly correct, and no corrections could be safely applied.

2. From 82° to 85° zenith-distance the logarithms of the refractions of the *Tabulæ* require diminishing by 0·00100.

3. From 85° to the horizon it seems expedient to give up the use of the mean refractions in Bessel's Supplementary Tables given in the *Tabulæ*, and to use those of the *Fundamenta*, diminishing the logarithm by 0·00066.

A projection of the star *Spica Virginis* on the moon's disk was witnessed on the 12th of March by C. R. Chalmers, Esq., at Barrie, Simcoe County, Canada West. His note of the occurrence runs thus: " The sky was cloudless, and I watched the star up to the bright edge. I then expected to lose sight of it, but it continued to advance on the face of the moon until I could distinctly see the limb *outside* the star. *Of this I am quite positive.* I counted several seconds from the first contact till the disappearance of the star, which was instantaneous. The star had a curious planetary appearance, which was also remarked by a friend at Toronto with a 4¼-inch refractor. The telescope I used is a 42-inch, by G. Dollond, of 2¾ inches aperture. Power 60." Mr. Chalmers adds that the superiority of the climate of Canada over that of England is very marked, a 3-inch aperture in Canada doing the work of a 4-inch in England.

Experiences with a Free-Revolver Stand for a Telescope at Sea, during a Voyage to Teneriffe in the Summer of 1856. By Professor C. Piazzi Smyth, F.R.S.E., Astronomer Royal for Scotland.

(*Continued from the December Number.*)

" The opportunity of making these experiments was afforded by the voyage that formed part of the astronomical expedition to Teneriffe last summer, and the vessel in which they were made

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was the yacht Titania, placed at my disposal for this purpose by the princely liberality of Robert Stephenson, Esq. M.P.

"The first point to get clear ideas upon was the amount as well as the character of the angular disturbances that the vessel underwent; to which end continual appeal was made to the Naval Clinometer, previously described. (See page 38.) The disturbances were at once found to be larger in angular amount, and quicker as to time, than had been expected. The results, therefore, of the new instrument were frequently checked by direct measurement on deck by vision and ordinary angular instruments, and were invariably so well confirmed in all their most characteristic features, that full confidence was felt in the clinometer; and it was found especially useful at those times, as at night, when the direct method was not available.

"A table of observations from June 26th to July 7th is subjoined, and represents the voyage from the Channel to the African coast; and from it we gather that the rolls of the yacht varied in number between 16 and 33 per minute, and in mean angular value from 3° to 20°; the pitches of the vessel being at the same time almost equal in number, but only of about one-fifth the angular amount of the rolls.

"Examining the table further, we find that in a calm outside the Channel the rolls were 21 per minute, of 3° each; that on a gale growing up, and having its swell unmixed by others, the number of rolls was lowered to 17 per minute, but their angular extent increased to 20°, returning again to its former characteristics, when after several days the wind died away to the west of the Portuguese coast. In the broken squally weather before making the trades, and in a confessedly cross sea, where two or more swells met, the number of rolls rose as high as 33 per minute with an average extent of 8°; while when the N.E. trade was once fairly entered, and its own long regular swell ruled supreme along the surface of the water, the number went down to 19 per minute, with an angular extent of about 10°. Day after day as we sailed in the trades, the wind, while it kept one invariable direction, constantly increased in velocity; and so did the rolls, preserving nearly the same number per minute, continually increase in angular magnitude until they had reached to above 20°. How much more they would have grown to it might have been interesting to have ascertained, but we had then, on July the 8th, arrived at the end of our voyage—the island of Teneriffe, situated in the midst of the brunt of the trade wind.

"Something more, however, deserves to be considered with regard to the rolls, viz., the angular magnitude of each roll, as distinguished from the quantities already given, which are the average of a large number.

"Thus, on July 6th, the following are the angular values, in degrees, of as many rolls observed during two minutes:—12, 10, 8, 6, 4, 10, 20, 16, 17, 21, 20, 19, 22, 14, 11, 18, 19, 13, 17, 10, 14, 13, 24, 31, 29, 23, 13, 21, 10, 17, 12, 12, 14.

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TABLE.

Date.	Latitude N.	Longitude W.	Wind.		Character of Sea.	Rolls of Yacht.		Angular Rolling in one Minute	Pitches of Yacht.		Rolls of Gimbal-table in Main Cabin.		Rolling of Gimbal-table in one Minute
			Velocity in Miles per hour.	Direction.		Number per Minute.	Angular Extent.		Number per Minute.	Angular Extent.	Number per Minute.	Angular Extent.	
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June 26	50°	4°	0	0	Calm.	21	3°	63°	21	1°	..	..	..
27	49	4	3	E.	Swell growing.	17	7	119	16	1	..	..	..
28	48	6	13	E.	Waves high.	17	12	204	16	1	45	8	360
29	46	9	15	N.E.	Waves running high.	17	20	340	19	2	43	7	301
July 1	43	11	2	S.	Broken sea.	20	9	180	21	3	40	..	280
2	42	11	2	N.	Glassy swell.	*(19	6	114	20	2)	..	..	..
..	..	..	..	..	..	20	4	80	20	2	..	..	..
3	41	11	5	N.W.	Smooth water.	18	4	72	..	..	..	..	..
At 4 P.M.	..	..	8	N.W.	Wind rising and cross sea.	33	8	264	22	3	..	..	..
At 6 P.M.	..	..	8	N.W.	Two swells interfering.	25	10	250	27	4	46	4	184
4	39	11	5	N.W.	..	21	6	126	22	2	..	..	..
5	37	12	8	N.N.E.	Rolls regular.	18	6	108	18	2	28	4	112
3 h.	..	..	10	N.N.E.	..	19	10	190	..	..	..	..	..
6 h.	..	..	12	N.N.E.	..	17	15	255	..	..	..	..	..
6	34	13	13	N.N.E.	..	19	16	304	18	1	27	8	216
7	31	15	15	N.E.	..	16	20	320	16	4	..	..	..

* These observations were by direct measurement on deck.

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"And, again, on July the 7th, the following series was obtained in 8 consecutive minutes:—

°	°	°	°	°	°	°	°
22	22	20	9	25	13	20	28
21	17	17	9	21	16	22	31
11	17	16	10	16	18	24	27
8	19	25	7	11	17	21	21
17	11	26	9	13	21	13	22
23	18	20	13	19	20	21	19
16	20	17	15	21	19	26	10
23	10	14	13	23	16	21	9
16	13	9	9	29	12	17	19
21	15	5	10	29	11	15	27
18	17	4	16	26	12	13	29
18	15	8	18	24	11	12	22
22	11	14	16	18	10	13	13
22	12	14	13	...	...	12	11
26	15	...	12	16	16	13	15
27	...	...	15	16	17	...	...
18	...	...	23	15	...	20	18

"These numbers, while vividly demonstrating the amount of disturbance of the yacht's deck, also indicate the very compound nature of the rolling of a vessel at sea; for, through the individual undulations, there run evidently others of a longer period, and through those others still longer. Indeed, I was never able to get any regularly recurring series of numbers; and after the passage of any given maxima and minima, there were sure to appear in the course of time others of yet higher order and greater intensity. On one occasion, after long watching, I caught a roll of 40°; and this did, while rolls of 31° did not, set things generally rolling and tumbling about in the cabin. As this species of actual and social disturbance below deck only occurred three or four times in the day, we may assume that there are amongst the waves of the sea undulations having a period of several hours, and with their crests from 30 to 40 miles apart.

"Such a result shows that no practical increase in the size of ships will altogether do away with their rolling at sea—that rolling which tends so to the discomfiture of the passengers, and the impossibility of taking telescopic observations. Neither can the old-fashioned plan of swinging tables avail anything. This was shown from principle in the paper of last year, and was found in practice on this voyage; for, as may be seen in the tabular representation of the observations, measures were made of the rolling of the dinner-tables on board the yacht; the tables being hung on pivots with a heavy weight below. They answered their purpose famously as dinner-tables for rough sea weather, for the plates and dishes kept their places marvellously. But when tested by

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the clinometer, or by the sun, they were found to be continually oscillating, through a less angle certainly than the yacht was rolling to, but so much more quickly, that the angular amount, multiplied by the number of vibrations, generally gave a larger total quantity of displacement in a minute for the swinging-table than for the yacht. In the little yacht the motions were doubtless much more excessive than in the larger class of ships now employed in long voyages; but if so, the occasion was all the more proper for testing the 'Free Revolver Stand,' as a means of eliminating from an astronomical instrument both the rolls and the pitches of a vessel.

"One of these instruments, on the principle already described, was on board, and was set in action on the 3d of July.

"The telescope mounted was a small one, magnifying 7 times; and having an eye-hole of one-eighth of an inch. The revolver was 1 foot in diameter, weighed 10 lbs., and was driven by two sets of wheel-work acting on either side of the spindle. The apparatus was arranged inside a sort of observatory box, into which the observer could insert his head and two hands, while openings for observations could also be made. The only convenient place on the deck for erecting the instrument was near the stern, where was the maximum of the up and down movement, and the look-out was over the quarter, with the full effect of the rolling; all this, however, was well for testing the new principle.

"The sailors were called up to work the driving-wheels, and when they had got up about 80 revolutions per second in the revolver, the wheels were withdrawn, the gimbal rings unclamped, and I had the satisfaction, for the first time that any one had had, of looking at sea through a telescope steadied by the same mechanical effort as that which preserves the constancy of the earth's axis in space.

"The following practical points were soon ascertained: first, that in spite of the egregious rolling of the yacht, which must be partaken of by the observer, but is happily not partaken of by a telescope mounted as ours, there is no difficulty in keeping the eye *en rapport* with the eye-piece, although in the present case the size of the eye-hole is extremely small; second, that the position of the platform of the telescope can be adjusted with great nicety in any direction as respects deviation from the horizontal plane, by simply pressing on one of the gimbal rings, in a direction 90° removed from that in which it is desired that motion should take place; and, third, that the telescope can be adjusted in azimuth or altitude by rack and pinion, without sensible derangement to the position of the platform.

"Having performed these adjustments, and brought the horizon of the sea into the field of view, I was delighted to find it remain there, absolutely uninfluenced by the rolling and pitching of the yacht; nay, it even remained bisected on the wire sufficiently long for the captain, the first and second mates, and several of the sailors, to look in and bear witness of the fact. They saw

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this consummation long desired at sea, and they took kindly to the instrument, though it was an innovation on nautical practice.

"In order to perfect the balance of some parts of the machine, which had left its maker's shop rather unfinished, I kept the sailors for several days working the driving-wheels while I was experimenting; they laboured at them with enthusiasm, indeed, rather too much so, for one unfortunate evening, when the instrument was so nearly perfect that I hoped in the course of the night to essay the grand nautical problem of observing an eclipse of one of *Jupiter's* satellites, the sailors, impatient of the difficulty of getting up immediately the full speed, clapped on a rope to the handle of the driving-wheel, and pulled away in such style, that they twisted the strong steel driving-axle in two, and were themselves laid flat along the deck.

"The practical sufficiency, however, of the single-wheel revolver stand, for correcting the rolling and pitching of a ship at sea, had been abundantly proved. And more than this, the azimuthal deviations of the yacht, which had been previously neglected as comparatively trifling, so long as rolling and pitching existed, were now found, when these were eliminated, and yawings left as the sole residual, to be absolutely so large, and so annoying to telescopic vision, as imperatively to demand attention and correction by the same revolver method also. On looking into the telescope, for instance, on the above-described stand, no change of plane from the horizon of the sea could be discovered; but any point in that plane, as a distant ship, was oscillating backwards and forwards in the horizontal direction twenty times in a minute; this being the effect of the azimuthal changes of the position of the yacht not having been eliminated as had been the rolling and the pitching.

"The application of a second revolver to the apparatus which was employed on board, to enable it to eliminate all the angular disturbances of the yacht would be easy, as indeed I described in my paper of last year, and such an addition should be a necessary preliminary to any further trials at sea."

Dr. William Stroud, in two letters to Dr. Lee, draws attention to two lunar eclipses which he imagines to be important as helping "to dispel some doubts and difficulties which still beset the chronology of the Christian era." The first of these he supposes to have happened at the autumnal equinox of the year B.C. 5, and the latter in the year A.D. 30, at the Paschal full moon corresponding to the time of the Crucifixion of our Saviour.

With regard to the first of these, it appears that there were two lunar eclipses in each of the years B.C. 4 and B.C. 5, one at the vernal and the other at the autumnal equinox; and they are